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(11) EP 1 179 380 A1

EUROPEAN PATENT APPLICATION (12)காறாக்க டாகள்களை மாகள் உறுமிர்கின் in accordance with 'Arti 158(3)' EPO சக்கள்கள் கண்ணிகள் இத்தி a shees arm were auditor ausistance. Me to pathoually a relates to a martenative calmester to the barry aumorer and (43) Date of publication: "near 3.0 phibesors bus retemble blight of B23K 9/02, B23K 9/23" (51) Int CI.7: B23K 9/02, B23K 9/23" (51) 13:02.2002 Bulletin 2002/07 Earlies of the sense bus returned at the control of the bulletin 2002/07 (51) Int CI.7: B23K 9/02, B23K 9/23" (51) Int CI.7: B23K 9/23" ((86) International application number: (21) Application number: 00950035.6 PCT/JP00/05296 (22)"Date of filing: 07.08.2000 The mandate of the property of the participation of the property of the proper tunes for conveying discrete gases which readily cause WO 01/10591 (15.02.2001 Gazette 2001/07) ibae's OMURA, Tomohiko nego na atroga o mensio (84) Designated Contracting States: comblew rent one or AT BE CHICY DE DK ES FI FR GB GR IE IT LILLY Kyoto-shi, Kyoto 606-8101 (JP) using the stabs referred to by the airreself. Light Back aco • KONDO, Kunio va besalbanti die reini 111 Sanda-shi, Hyogo 669-1324 (JP) s prise is formed by the signated Extension States: of the control of the printic ALLITLY MK RO SI to some or vd against agid a mic Nishinomiya-shi, Hyogo 662-0881 (JP) sarothog (30) Priority: 06.08.1999 JP 22467199 of analyse of a series and a ser ri nitaHAMADA, Masahikonorg sus segiq lenoz appa Amagasaki-shi, Hyogo 660-0892 (JP) w radi bar side edge of the strip (71), Applicant: SUMITOMO METAL INDUSTRIES, LTD. Diocesses other than those mentioned above as lon-S Saka-shi, Osaka 541-0041 (JP), Heini a grimno as formital salar (74) Representative: Uchida, Kenji et al to segra liew w mas Cabinet Fedit-Loriot 38 avenue Hocheamot sayt iding the side edge in side coar in order to join portions of (72) Inventors: 75008 Paris (FR) the thick place rockinar [0007] In producing these large-diameter thick-wall pipels the submerced are welding method diameter [0007] to as "SAW method" is widely used in producing large-(54) am MARTENSITE-STAINLESSISTEEL-WELDEDISTEEL-PIRE IN 11 on blow revet legant isset to least conducted in some instances (57) This invention relates to a large-diameter, thick are superior in corrosion resistance; in particular stress wall martensitic stainless steel welded piper For this lease corrosion cracking resistance (SCC resistance). The welded pipe; the size of the raised weld bead portion on seed sulfide stress corrosion resistance (sour gas resistance) the inside surface is restricted to be small based on a more and carbon dioxide corrosion resistance can be further conditional formula derived by considering the bead wolf improved by selecting the chemical compositions. This width and height and the yield strength of the base metal welded pipe is very well suited for use as a pipe for a and of the weld metal. As a result, the base metal portion design place for conveying a crude oil and a natural gas with and pipe inside surface seam portion of this welded pipe not dehydration treatment, which is highly corrosive to · is high Therefore the use of a more compaint of a lighter has been begun for the architical of pipes to impline contained. while criticis the artivolation enurgment. The material having higher correspond resistance incorring statisfiers steel [0010] In this current maker deposition couponed not platform therefor is required a exercision together and this fact to very accepting and the captore of a comatacidate of Differ wells for example consental wells, which capper have been distentioned appendicable view of the police of the course of the property of the continuence of t platform and collectively treated the effection and modified [0011] In high-letitud, distance et porthi i teude 70" or highe, whor's fatore explorance cap uned, free eya tok oil wells in the North Seal the platform constitution itself is difficult from the viewpoint of a pass catherane seal in this case it is necessary to transport crude oils including without dehydration transminst [0012] With a chib angular large-dam at the cavallacided paragraphic (and the ingmissic in highwork has a are more that into the second community which readily compaive additional motals [0013] Some stainings their which are hordy comogion-resistant and suitable for convoluncial intuities et above and scamples pities of electric resultance welked pipes or leser welded pipes made mereof with a relatively small that one in relatively thin was the word poposed. As hyplange-distinctor wigh-wear wilded his tomade of stances and residencies and beautioned as therefore an disclosed in JP Keise. However, and JP Keise However, and and JP Keise However, and the stances are the stances and the stances are stances. ខាឡានូលវ ហ៊ូរ៉ូ remain stances stock contained -- 1.85 in a graprom There 42 A. Ad tones seems 1 3132 H Walter School of the F

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TECHNICAL FIELD

[0001] This invention relates to a martensitic stainless steel welded pipe excellent in corrosion resistance, in particular in stress corrosion cracking resistance. More particularly, it relates to a martensitic stainless steel large-diameter and thick-wall welded pipe exceeding 20 inches in outside diameter and exceeding 0.5 inch in wall thickness, which is used in a pipeline, in particular a trunk line, for conveying a fluid such as oil or natural gas readily corroding metals.

10 BACKGROUND ART THE TOBER STORE PROGRAMMENT (88)

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[0002] Large-diameter, thick-wall stainless steel pipes exceeding 20 inches in outside diameter and 0.5 inch in wall thickness are widely used in pipelines, in particular trunk lines, for conveying oils or natural gases which readily cause corrosion of metals.

[0003] Such large-diameter, thick-wall pipes are generally produced by a process which comprises forming a thick plate or hot strip into an open pipe or spiral form by bending and then welding the joining portions together. The steel pipes produced by such a process are generally produced by a process which comprises forming a thick plate or hot strip into an open pipe or spiral pipes. The steel pipes produced by such a process are generally produced by a process which comprises forming a thick plate or hot strip into an open pipe or spiral pipes.

[0004] UO pipes are produced by a forming process comprising the steps referred to by the alphabetic letters (U and O) indicative of the name given thereto. In this process, a thick plate is formed into an open pipe form bent by using a U press, then the side edges are joined to each other to form a pipe shape by means of an O press and the joining portions are welded together.

[0005] Spiral pipes are producted by forming a hot strip into a pipe shape by spirally bending the hot strip in succession and then welding the joining portions together, side edge to side edge of the strip.

[0006] Processes other than those mentioned above are also available for the production of large-diameter, thick-wall pipes. For example, there is a process which comprises forming a thick plate into a pipe-like shape using a 3-roll type forming machine called roll bender and then seam-welding the side edge to side edge in order to join portions of the thick plate together.

[0007] In producing these large-diameter, thick-wall pipes, the submerged arc welding method (hereinafter referred to as "SAW method") is widely used. In producing large-diameter, thick-wall pipes by welding, one-layer welding is generally-carried-out-from-each of inside and outside of the pipe. Further, when the wall-of-the material is thick, multipass (at least three) layer welding, in which two or more bead layers are formed from one or both sides, may be conducted in some instances.

[0008] Heretofore, In producing large-diameter, thick-wall welded pipes to be used in conveying fluids, such as olls and natural gases; readily causing corrosion of metals, steel plates made of carbon steel or low alloy steel containing at most about 1%, by mass of Cr have been used as the base metals together with welding materials. The reason why large-diameter, thick-wall welded pipes made of carbon steel, which is inferior in corrosion resistance, have been used is that carbon steel is economically more advantageous. However, carbon steel is poor in corrosion resistance. Therefore, for pipelines constituted of welded pipes made of carbon steel sit has been a common practice to subject the crude oil or natural gas obtained from an oil well to dehydration to the reduce the corrosiveness of the fluids bog

[0009] However, the cost of construction of the dehydration equipment and the platform for the installation thereof is high. Therefore, the use of a more corrosion-resistant material has been begun for the production of pipes for pipelines while omitting the dehydration equipment. The material having higher corrosion resistance includes stainless steel.

[0010] In this case, neither dehydration equipment nor platform therefor is required at exploration locations and this fact is very advantageous to the exploration of small-scale oil of gas wells, for example horizontal wells, which cannot have been drilled. Specifically, it is an advantage that crude oils can be conveyed through such pipelines to an existing platform and collectively treated there for dehydration.

[0011] In high-latitude districts at north latitude 70° or higher where future exploration is expected, for example oil wells in the North Sea, the platform construction itself is difficult from the viewpoint of waves on the sea. In that case, it is necessary to transport crude oils through pipelines without dehydration treatment.

[0012] With such background, large-diameter, thick-wall welded pipes enabling the omission of dehydration treatment are more and more desired for conveying fluids readily corrosive against metals.

[0013] Some stainless steels which are highly corrosion-resistant and suitable for conveying such fluids as mentioned above, and seamless pipes or electric resistance welded pipes or laser welded pipes made thereof with a relatively small diameter and a relatively thin wall, have been proposed. As for large-diameter, thick-wall welded pipes made of stainless steel, welded pipes and base metals therefor are disclosed in JP Kokai H10-60599 and JP Kokai H12-8144, for instance.

[0014] For the above application, martensitic stainless steel containing 9-13% by mass of Cr are used from the economical viewpoint. This is because martensitic stainless steel has, in addition to the economical feature, sufficient

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corrosion resistance under such circumstances as mentioned above, and is excellent in hot workability and, therefore, can readily be made into thick plates or hot-rolled plates, which are materials for the production of welded pipes.

[0015] It has been considered that these martensitic stainless steels used for base, metals and the weld metals of

seam weld portions are excellent in stress corrosion cracking resistance (hereinafter referred to as "SCC resistance"), carbon dioxide gas corrosion resistance (hereinafter referred to as "CO₂ resistance") and sulfide stress corrosion resistance (hereinafter referred to as "SSC-resistance" or "sour gas resistance").

[0016] However, it has been revealed that when welded pipes made of martensitic stainless steel are used in a pipeline for conveying a corrosive fluid without dehydration, stress corrosion cracking (hereinafter referred to as "SCC") tends to occur at the weld portion of the pipe inside surface. In particular, with large-diameter, thick-wall welded pipes produced by the SAW method without cutting off the weld bead on the pipe inside and outside surfaces, the tendency toward occurrence of SCC is significant. Furthermore, it has become apparent that even if the pipes have SCC resistance, the base metal and weld metal may be poor in sour gas resistance and the weld metal may be high in weld hot cracking susceptibility in some instances.

DISCLOSURE OF THE INVENTION PROBLEM TO BRIDGE STANDARD ST

The object of the present invention is to provide a large-diameter, thick-wall martensitic stainless steel welded pipe excellent in corrosion resistance, in particular stress corrosion cracking resistance (SoC resistance); at the base metal portion and the seam weld portion of pipe inside surface and, further, excellent in Suffide stress corrosion resistance (Sour gas resistance) and carbonidoxide gas corrosion resistance (CO2 resistance); acto be play and [2000] [0018] rechestainless steel welded pipe of the inventionals composed of acbase metal which has a stainless steel containing not more than 0.1% by mass of C and 7-20% by mass o

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where L: the length of the portions of the seam weld bead showing a value of h which exceeds 1.25 as calculated by the expression (2) shown below:

0-4 t 6Mc - 2M1 - 3 301 1/3 5 6 0

$$h = \{1 + (2 \times H/W)\} \times (YS_{B100}/YS_{w100})$$
 (2)

where

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[0019] As for the metallugical microstructures of the base metal and weld metal, those of the base metal are desirably constituted of 55-90% martensite phase and 10-45% ferrite phase and those of the weld metal are desirably constituted of 70-95% martensite phase and 5-30% austenite phase, on the volume % base metal are desirably constituted of 70-95% martensite phase and 5-30% austenite phase, on the volume % base metal are desirably constituted of 70-95% martensite phase and 5-30% austenite phase, on the volume % base metal are desirably constituted of 70-95% martensite phase and 5-30% austenite phase, on the volume % base metal are desirably constituted of 70-95% martensite phase and 5-30% austenite phase, on the volume % base metal are desirably constituted of 70-95% martensite phase and 5-30% austenite phase.

[0020] The contents of chemical components other than C and Cr of the base metal and of the weld metal of the seam weld portion of the welded pipe of the invention are desirably within the respective ranges shown below:

For the	he base meta	al, on the n	nass % basis: 3887-77	, , , , , , , , , , , , , , , , , , ,
Si	0.01-1%,	sol. Al	not mole than 0.05	
. Mn	_0.05-2%,	V	-0-0.5%,	
Ni	0-9%,	Zr	0-0.5%,	
Mo!n	.0-5%,-	Car	0-0.05%;	
W	0-6%,	Mg	0-0.05%,	

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ता र वर्गास्तर इत्तरहार दर्गातस्थान र	" 9 61!	CO _E resist	Balance	Fe and impurities;	र १८३५ । इ.स. १८५७ हो १५ होन
s in those she leads assimble :	For th	ie weld meta	ıl, on the ma	ss % basis:	an airmean long to be size. Soft that it has a room to be size.
					คนที่ และที่คน องกายที่ ที่สำคัญ เด็บคนึ่ง
meter, thick-wall violand pipes	#Mn?#	0.05-2%,	11 V 71 2733	1 0-0:3%] odig ədi to ne:	lendanc occurry the west cost
outside surfaces the terdencia	oNI or	€0±10%; 50°	Zr ^ 5		nroduced by the SAM method
n if the biper have SOC resist	[,] VMo ⁵⁵ 5	0-5%,	-Ca	0-0.03% กษา โกคอากิดอา	Loward became ice of 8:77 is s
ua blaw ni diglal od vernilistom	W	0-3%	Mg	70-0-03%	ica , a lalem sees, mis eom.
	Cu	0-3%,	Ti	not more than 0.1%,	e eksekte o stisokotibility in komc
			Balance	Fe and impurities	EANNERHALED AND SECOND

[0021] re-For both the base metal and weld metal, the contents of P, S and O (oxygen) among the impurities are desirably asafollows Panotimore than 0:025% Singet more than 0.01% and Othot more than 0:01%; while the content of N is desirably not more than:0002% for the base; metal and not more than 0.05% for the weld metal. 9 விற்ற கழியார் இதன [0022] The welded pipe mentioned above is a basic welded pipe of the present invention and the welded pipe of the inventions which satisfied the above conditions is excellent in SCC resistance; in particular all the base metals used for pipe production may be the one las hot rolled. Further, this pipe shows sufficient SCG resistance and GO2 resistance even when the heat-treatment of the heat affected zone of the base metal and of the weld metal portion is omitted after seam weld metal which is a stainless steel containing not more than 0.1% by mass of Cland 7-20% by mass ogniblew [0023] and The contents of Cra Ni; and Thin the base metal of the basic welded pipe of the invention desirably fall within the respective ranges given below and further satisfy the relations (3) and (4) given below: In this case, even when the base metal is as hot rolled, it is excellent not only in SCC resistance but also in sour gas resistance and seven when the heat treatment of the weld portion after welding is omitted, these resistances are satisfactory.

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30	· t >	Cr Ni	11-20%, 3-7%.	Ti	not more than 0.05%,	
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	,	•			·	where twees the measurement
05			Cr + 1.5Mc	o - Ni	- 0.4Cu - 14 ≧ 0	(3)
35	(2)		301 W 3 V	· ;	Control of the second	
	· .		Cr + 1.5Mo	- 2Ni -	· 0.8Cu - 12.5 ≦ 0	(4)
			•			TOTATION AND

[0024] For the above basic welded pipe, it is also desirable that the Cr, Ni, Mo and Ti contents of the base metal as shown below are combined with the Cr, Ni, Mo and Ti contents of the weld metal as shown below and that the chemical composition of the weld metal satisfy the relations (5) and (6) given below. In this case, even when the heat treatment of the weld portion after welding is omitted, the base metal and weld metal are excellent in toughness and strength and the weld metal portion is excellent with respect to sour gas resistance and weld hot cracking susceptibility.

e base motal wio desirably	Base metal:	
	Cr, 15-20%, Mos. 1-5-4%, Nisse 74-7%;	of 70-95%, madensite of
1 .	Weld metal:am การแกรงการ นาการเการาชาการเการาชาการเการาชาการาชาการเการาชาการเการาชาการเการาชาการเการาชาการเการ	
	Cr 11-18%, Mo, 1.5-4%, or 1.5-4%,	•
	-1 ≦ Cr + Mo - 1.7Ni ≦ 13 - 220 x O (oxygen) M	(5)

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ANDER For the welled his in encommont, the remember of the encountry of the convexes of the encountry acabilia interitivals ent of a based blow out 25 ≤ Cr.+ Mo +,1.8Ni ≤ 30 ebisnop yo cuto issuera epatria obtani e(6)q and the visid strength of the base metal and or think in the learner actor 100°C. As a result the critical con-[0025] sain addition to the welded pipe mentioned above, the basic welded pipe according to the invention, when the base metal and seam weld metal have the chemical compositions respectively given below on the mass % basis, shows? 5 the highest SCC resistance real COC on grains of the constraint and the south of the semi-interest and the sem is significant. Therefore, the welded pipe of the invention cut out good SCC resistance even in figids comaining high Base metal: Of 1001 Turch on the emeanment forth to another the an [0333] The reason why उर्त प्रहात इटक्षीमाड इंग्रेसम not more than 0.1% Ill will be not norm not more than 0.5%, 10 Mnow not more than 1%, . .. Cu and w .053% selected of another procubors of [Sedu] a al batti vilarenco (e il dublax signices stool oo taming 1 of lea%8,0.00 4. to V Grat 59/1/2/mod one phase and an energically phase or a super duplex ilteroless steet/%10:0-00/2 nor tablic at 1994 by mass (%950 (if till) v eld materials mentioned esotrilets volgum regue e litWink 1041%, esad ent et entre le Balance ric Ferand impurities, le el claise veloub esti evode <u>ามกับตาล แบบ ควายความคลา มาใช่ดู ๓๐๐๐ ๗ "ดับตราย หาติดเล</u> class chianostam in long 15 anaism blew edt ingan a <u>in tong prain aut en aafrea, bedoombo pr</u>ese put power i- notem Projected are ing inose The minor more than 0:1% the octoor learned a series di sCam Inot more than 0.05%, to the section is that since The Curronization of the contract of the contr unicered ad pelidical lear ∴Site ∉ not more than 0.5%, an audienite phase. In radies where a reng/2:0-03 is user, V The second state of the condition of th -uetsne ur pur eseud et l'oftet. 6-50% eu seseu danc a CE do cind 10-0304% inspiration pulliment eut engleue it pur 0-9% 0-0.01%, [0035] The weld metal taving dual passion structure and [2003] Balance Fe and impurities: and austenite present shows more markable decreas having substantially single-phase martensite micros, urtuing the yield strength of the weld metal te lower The above-mentioned welded pipe of the invention is most suited for use as a pipe for a pipeline for conveying crude oil or natural gas without dehydration is to be seen and seen and the term "large diameter" means not a course of the invention is directed to a large-diameter, thick-wall welded pipe and the term "large diameter" means not a course of the invention is directed to a large-diameter, thick-wall welded pipe and the term "large diameter" means not a course of the course of th less than 20 inches (508 mm) and the term "thick wall" means not less than about 0.5 inch (12.7 mm). The terms "martensite phase as the main constituent" means that the martensite phase proportion exceeds 50% by volume, and at the weld bead foe on the bibe institus surface is prevent, the most be means described below bence SCC BRIEF DESCRIPTION OF THE DRAWINGS hardly occurs 10036] In the following the welded pibe of the invention is the representation by % or **[0028]** the content of each chemical component means % our raper Fig. 1 is a schematic drawing illustrating the sectional structure of the seam of an ordinary large diameter, thick-35 wall welded pipe. Fig. 2A and Fig. 2B are drawings illustrating the method of providing a bending stress for the SCC resistance and sour gas resistance tests as used in the examples. Fig. 2A is a sectional view of a jig for providing a bending stress. and Fig. 2B is a drawing illustrating a state of a 4-point bending stress being imposed. Fig. 3 is a schematic representation of the sectional structure of the weld made from the single pass weld material 40 h = 11 + (2 x HAW) × 1 3 = 13 YS + 1001 (S) used in Examples 1 and 2. Fig. 4 is a drawing showing the site of test specimen sampling for the tests made in the examples, namely the site of collection of 4-point bending test specimens from the single pass weld material for SCC resistance and sour (mm) vy labelities and sour and sour and source that it is a superior that the superior that it is a superior that the superior that it is a superior to the superior that it is a superior to the superior that it is a superior that it is a superior that it is a superior to superior that it is a superior tha gas resistance testing. gas resistance testing.

Sy one 0°00° to the residual to the steer of the steer and the steer and the steer and the steer and the site of test specimen sampling for the tests made in the examples, namely the site of test specimen sampling for the tests made in the examples, namely the site of test specimen sampling for the tests made in the examples, namely the site of test specimen sampling for the tests made in the examples, namely the site of test specimen sampling for the tests made in the examples. of collection of 4-point bending test specimens from the welded pipe for SCC resistance and sour gas resistance and sour gas resistance. . pnitest is taken as a standard index value. And meleon is the west need direction of these convexes of the welded cope where hiexceeds 1.25 is determined. Lishophisages, the following relation (1) BEST MODES FOR CARRYING OUT THE INVENTION [0029] As mentioned above, crude oils and natural gases, when the treatment for dehydration thereof is omitted, may cause corrosion of metals. When large-diameter, thick-wall martensitic stainless steel welded pipes produced by the SAW method are applied to pipelines for conveying such fluids, stress corrosion cracking (SCC) generally tends of (1) nonsier one do (1) nonsi 55 cause thereof and have now completed the present invention.

19031] Fig. 1 is a schematic drawing illustrating the sectional structure of the seam weld of an ordinary large-diameter.

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thick-wall welded pipe.

[0032] For the welded pipe 1 according to the invention, the size and number of the convexes of the weld on the pipe inside surface are restricted by considering the width and height of the weld bead 3 on the pipe inside surface and the yield strength of the base metal and of the weld metal at the temperature 100°C. As a result, the stress concentration at the weld bead too decays do by the shape of the weld bead is suppressed and it becomes possible to prevent the occurrence of cracking caused by the difference in strength between the base metal and weld metal at high temperatures up to 100°C. In particular, the synergy effect in preventing the SCC resulting from those two effects is significant. Therefore, the welded pipe of the invention exhibits good SCC resistance even in fluids containing high concentrations of chlorides and CO₂ at high temperatures up to about 100°C. Steppe page 1

[0033] The reason why-SeG-tends-to-occur at the toe 4 of the-weld-bead-3-on-the-pipe inside surface may be mentioned more specifically as follows.

[0034] In producing martensitic stainless steel welded pipes, the weld material (welding wire) generally used is a duplex stainless steel containing not less than 22% by mass of Cr and comprising a ferrite phase and an austenite phase or a super duplex stainless steel containing not less than 25% by mass of Cr of the weld materials mentioned above, the duplex stainless steel is superior in corrosion resistance to the base metal while the super duplex stainless steel is superior in corrosion resistance and strength to the base metal. When, on the other hand, a martensitic weld material having the same component series as the base metal is used, the weld material is selected among those having a chemical composition allowing the formation of an austenite phase in the weld metal. The reason is that since martensitic stainless steel is high in weld cold cracking susceptibility, the cold cracking should be inhibited by forming an austenite phase. In cases where a ferrite phase is present in the weld metal, weld hot cracking tends to occur readily and therefore the metallurgical microstructures should comprise two phases, namely a martensite phase and an austenite phase.

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[0035] The weld metal having dual phase microstructure containing austenite phase shows more markable decreases in strength, in particular in yield strength, at high temperatures up to about 100°C as compared with base metals having substantially single-phase martensite microstructures. Therefore, the yield strength of the weld metal is lower than that of the base metal in a high temperature service environment. In particular when used in a pipeline, the pipe undergoes hoop stress due to tension during use and, therefore, greater strains are imposed on the weld metal inferior in yield strength than on the base metal. The reason why SCC tends to occur at the weld bead toe is that the tensile stress and the stress concentration in the weld bead overlap with each other, which result in an excessive increase in the strain on the weld metal side of the weld bead toe. Where the welded pipe of the invention is concerned, the strain at the weld bead toe on the pipe inside surface is prevented from occurring by the means described below, hence SCC hardly occurs.

[0036] In the following, the welded pipe of the invention is described more specifically. The representation by % of the content of each chemical component means % by mass.

Shape of the weld bead on the pipe inside surface:

[0037] According to the invention, the height index h of the weld bead on the pipe inside surface is defined by the following equation (2):

Some series being a constant of the equation of a deposition of the pipe inside surface is defined by the sound in the pipe inside surface is defined by the sound following equation (2):

Some series being income that the pipe inside surface is defined by the sound in the pipe inside surface is defined by the sound in the pipe inside surface is defined by the sound in the pipe inside surface is defined by the sound in the pipe inside surface is defined by the sound in the pipe inside surface is defined by the sound in the pipe inside surface is defined by the sound in the pipe inside surface is defined by the sound in the pipe inside surface is defined by the sound in the pipe inside surface is defined by the sound in the pipe inside surface is defined by the sound in the pipe inside surface is defined by the sound in the pipe inside surface is defined by the sound in the pipe inside surface is defined by the sound in the pipe inside surface is defined by the sound in the pipe inside surface is defined by the surface is defined by the sound in the pipe inside surface is defined by the sound in the pipe inside surface is defined by the sound in the pipe inside surface is defined by the sound in the pipe inside surface is defined by the surface is defined by the

Fig. 3 is a sommatic representation of the sections structure of the weld made from the single pass weld mareria

(2) used in Examples 1 and 2. $(001w^2N_{0018}^2N) \times ((WH \times S) + 1) = d$ Fig. 4 is a drawing showing the site of test specimen sampled the tests made in the examples namely the site.

[0038] In formula (2), H (mm) represents the height of the weld bead 3 from the pipe inside surface, W (mm) the width of the bead, YS_{B100} (MPa) the yield strength of the base metal at 100°C and YS_{w100} (MPa) the yield strength of the weld metal at 100°C.

[0039] For the welded pipe of the invention, the value of the index h defined by the above formula (2) which is equal to 1.25 is taken as a standard index value. And, the length L, in the weld bead direction, of those convexes of the welded pipe whose h exceeds 1.25 is determined. L should satisfy the following relation (1):

[((t)29] As mentioned above, and to oils end network x.2.0 ≥ 1 - the treatment for dehydration thereof is emitted may be corresion of metals. When large-diameter, this was traitic stainless stool welded pides produced by

[0040] The reason why SCC resistance evaluation is made based on the combination of h = 1.25 and relation (1) is that this combination enables the most accurate appreciation of the SCC resistance.

[0041] In the case of spiral welded pipes, the term "in the weld bead direction" as used herein means the direction of the fusion line of the spiral seam. The above standard is very effective for evaluating, for SCC resistance, welded pipes particularly intended for conveying high-temperature fluids untreated for dehydration, such as crude oils rich in

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chlorides and containing carbon dioxide gas in section of the lower too blaid outlined and light is governous [0042]. Referring to the above formular(2), the yield strength values at 100°C for the base metal and weld metal are employed because, in those pipelines where the welded pipe of the invention is mainly used, the pipe inside temperature is generally at most about 00°C/L moust and office are increased as favor each off to motion in our properties of the invention is mainly used, the pipe inside temperature is generally at most about 00°C/L moust and office are increased as favor each office and increased and the invention of the inventio

[0043] The metallugical microstructures of the base metal should consist mainly of a martensite phase containing a ferrite phase Although the base metal may comprise a full martensite phase, a thick plate or hot rolled plate with a single phase, which is the material for a welded pipe, is excessively high in strength, hence the conditions of use thereof are restricted; for example, it is ress workable and the welded pipe as welded condition can hardly be used without heat treatment after production. Therefore, for obtaining an appropriate level of strength, the metallurgical microstructures of the base metal should be such that the martensite phase proportion exceeds 50% by volume and a ferrite phase is contained therein. The ferrite phase proportion may be 0% The martensite phase volume percentage in the metallurgical microstructures is desirably 55-90%. The ferrite phase accounts for the remainder and the volume percentage the reof is desirably 10-45%! amoas at a which compared it entire below a to not bubong and not later associant [0044] The strength of the base metal as hot-rolled or as welded for pipe production is desirably equivalent to the X-80 grade of strength (551 to 689 MPatin yield strength) as defined in the relevant API standard. For attaining sideh strength; it is necessary that the microstructures contain a soft ferrite phase; namely the δ-ferrite phase; as a second phase. When the martensite phase proportion exceeds 90% by volume the strength becomes excessively high and local deformation may occurrent the weld portions during the construction of aspipelines it is therefore desirable that the martensite phase account for not more than 90% by volume namely the ferrite phase account for not less than 10%? so as to suppress the increase in strength. When, on the other hand, the martensite phase proportion is less than 55% by volume, a yield strength corresponding to the X-80 grade may not be secured in some instances. Therefore in the corresponding to the X-80 grade may not be secured in some instances. Therefore in the corresponding to the X-80 grade may not be secured in some instances. and on the weld hot cracking susceptibility of the 1800-25 is 55-20 is a susceptibility of the 1800-25 is a susceptibility of [0045] noThe volume ratio between the martensite phase and ferrite phase in the metallurgical microstructures can be determined by the point counting method. According to this method, microscopic photographs of the metallurgical microstructures at a magnification of ៅ 000 (7.3 cm x 9.5 cm) are taken in 5 fields and further 44 foldentargements thereof are printed. Then, unit lines are drawn on these photographs at 5-mm pitches and all the grids are examined while giving appoint when a grid is within a martensite phase, 0 (zero) point when it is within a feirite phase and 0.5 point when it is on the boundary between a martensite phase and a ferrite phase a ferrite phase and a ferrite phase and a ferrite phase and a ferr calculated and the proportion of each phase is determined by dividing the score obtained in the above maniner by that total number? This value represents the volume proportion of the relevant phase is a substant fraction of the relevant fr [0046] The metallurgical microstructures of the weld metal mainly comprise a martensite phase and contains an austenite phase ា he microstructures should contain an austenite phase so that the strength toughness; cold workall bility and weld hot cracking resistance of the weld metal portion can be secured The austenite phase proportion is desirábly:5-30% by:volume / with the martensite phase proportion thus being:70-95% by volume / with the martensite phase proportion thus being:70-95% by volume / with the martensite phase proportion thus being:70-95% by volume / with the martensite phase proportion thus being:70-95% by volume / with the martensite phase proportion thus being:70-95% by volume / with the martensite phase proportion thus being:70-95% by volume / with the martensite phase proportion thus being:70-95% by volume / with the martensite phase proportion thus being:70-95% by volume / with the martensite phase proportion thus being:70-95% by volume / with the martensite phase proportion thus being:70-95% by volume / with the martensite phase proportion thus being:70-95% by volume / with the martensite phase proportion thus being:70-95% by volume / with the martensite phase proportion thus being:70-95% by volume / with the martensite phase proportion thus being in the phase proportion thus being in the phase p the fusion welding method, which tends to increase an O (oxygen) content in the weld metal portion, is used, the microstructure containing austenite phase is effective for securing toughness theo nM ed to fimil required to 1800] [0047] The austenite phase volume percentage (%) in the martensitic microstructures can be determined by the following methods For a pipe or plate, the intensity ratio of the austenite (220) diffraction pattern to the martensite phase {2:11} diffraction pattern is determined for each of three sections; namely a section in the direction of rolling; a section perpendicular to the direction of rolling and a section parallel to the surface by the X-ray diffraction method using the Co-Krarray as the primary Xiray. The austenite phase volume percentages are the producted based on the meastured.

correctionsibing a standard sample composed of marsensitic stainless stand austentitic stainless stainless stand austentitic stainless stand austentitic stainless stand austentitic stainless stand austentities of the property of the prope

[0048] veSince, however the martensite phase and austenite phase differ in diffraction pattern intensity, hence errors

may occurre due to the differences in characteristics from apparatus to apparatus necessary to make intensity

values for the three sections and the mean values of the results is calculated.

weld metal

the weld metal portion and welding heat affected zone at the weld bead toe. When such a welded pipe is applied for

conveying a high temperature fluid not treated for dehydration but containing chlorides in large amounts under a carbon dioxide gas environment; it is apt to undergo stress corrosion cracking. Further, in an environment containing a trace amount of hydrogen sulfide its sour gas resistance decreases markedly: and divide a large gas resistance decreases markedly: and divide a large gas resistance decreases markedly: and divide a large gas resistance decreases markedly: and divide gas resistance decreases markedly: and divide

[0051] 61 Cr. Cr.is an element improving the corrosion resistance, in particular the CO2 resistance. When the Cr content

of the base metal is less than 9% and that of the weld metal is less than 7%, the CO2 resistance is not sufficient for the pipe-to-be used in conveying a carbon dioxide-containing fluid readily corroding metals, for example natural gas or crude oil with no dehydration treatment. Therefore, the lower limit of the Cr content is set to 9% for the base metal near treatment after production. Therefore, for obtaining on at leave of strength, in Istem blew, edition of the strength of Williams. [0052] a The upper limit of the Ciscontent is set to 20% for both the base metal and weld metal. When the Cr content of the base metal is over 20%, the martensite transformation temperature (Ms-point) lowers, hence it is difficult to obtain metallurgical microstructures mainly comprising a martensite phase., In: particular when a plate as hot rolled is used as the base metal for the production of a welded pipe, it becomes difficult to secure the desirable lower limit; namely:55% by volume atouthe martensite phase proportion at the state of the state asked out to discrept and the phase proportion. [0053] miWhen the Grecontent of the weld metal is over 20%; ferrite phases tend to be formed. In that case, the metal allurgical microstructures of the weld metal portion will not become dual phase microstructures mainly comprising a martensite phase and containing an austenite phase and screece and acceptance of the martensite phase proportion exceeds and sensite phase and containing an austenite phase and screen are sensite phase and containing an austenite phase and screen are sensite phase and containing an austenite phase are screen as a sensite phase and containing an austenite phase are screen as a sensite phase and containing an austenite phase are screen as a sensite phase are screen as a sensite phase and containing an austenite phase are screen as a sensite phase are screen as a sensite phase are screen as a sensite phase and containing an austenite phase are screen as a sensite phase are screen as a sensi [0054] it Therefore, the Cricontent of the base metal should be 9-20% and that of the weld metal 7-20%. Since the Cos resistance is more improved as the Cr content is higher, a desirable Cr content range is 11-20% more desirably 15-20%, for the base metal and 11-18% more desirably 11-15%, for the weld metal or essence entress of escape [0055] The Cr content exerts important influences also on the sour gas resistance of the base metal and weld metal and on the weld hot cracking susceptibility of the weld metal. These corrosion resistances are also influenced by the contents of other elements, for example Ni, which are austenite phase forming elements. Therefore, it is recommended that the Crocontent is selected considering the contents of such elements, as mentioned later hereing vo benimes to [0056] so The elements mentioned below are elements which may be contained in the base metal when necessary mentioned below are elements which may be contained in the base metal when necessary mentioned below are elements which may be contained in the base metal when necessary mentioned below are elements. [0057] EX Sis Si is an element effective for deoxidation of the molten steel in the production of the base metal and in deoxidations of the fusion zone in the step, of welding. Since, however the toughness tends to decrease when the Si content is higher, than 1%; the content of Sigwhen it is used as the deoxidizer, also desirably not more than 1% for the base metalras well as for the weld metals A more desirable upper limit is: 0.5% a rione to no ino dord ent bas betalrals as for the weld metals A more desirable upper limit is: 0.5% a rione to no ino dord ent bas betalrals. [0058] For producing the deoxidizing effect of Si, It is desirable that the Si content be not less than 0.01%: A more [0046] The metallurgical microstructures of the well in the second second and according to the metallurgical microstructures of the well in the second secon [0059], Accordingly, a desirable content of Si, when it is contained, is 0:01-1%, more desirably 0:05-0.5% stinetaus [0060] to Mn: Mn: is an element effective for improving the deoxidation of the molten steel in the production of the base metal, or the deoxidation of the fusion zone in the step of welding; and the hot workability of the steel. For producing these effects, it is desirable that its content is not less than 0.05% for both the base metal and weld metal. noteur ent [0061] The upper limit of the Mn content is preferably set at 2% for both the base metal and weld metal When the Mn; content; of the base metal is: over 2%, segregation of Mn tends to occur, within the slab for the production of the base metal; hence a decrease in toughness may occur due to the segregation of Mn; and also the SCC resistance tends to decrease. A desirable upper/limit of the Mn content of the base/metal is 1%. When the Mn content of the weld metal/exceeds/2%; the toughness and SCC:resistance are aptito decrease as pallor to notice to est of relucibnemed [0062] and Accordingly, when Mn is added, the Mn content is 0.05-2%, desirably 0.05-1%, for both the base metal and weld metal. values for the three sections and the mean values of the case the executated

is higher than 9%, the Ms point lowers and the strength tends to decrease. A more desirable upper limit is 7%.

[0064] In the weld metal, Ni is effective for increasing the austenite phase proportion. Therefore, when it is necessary to obtain such effect, Ni is contained. For producing that effect, the Ni content is desirably not less than 2%, more desirably not less than 5%. When the Ni content of the weld metal is over 10%, the effect of Ni saturates and an increased cost is caused, hence the upper limit of the Ni content of the weld metal, is preferably set to 10%. It is desirably 3-9%, more desirably 3-7% of 4-7%. When the weld metal contains Ni, the content thereof is desirably 2-10%, more desirably 5-10%. Since Co has almost the same effect as that of Ni, Co may be substituted for part of Ni, and content is desirable and of [0066] its Mor. W and Cu. These elements are effective for improving the sour gas resistance of the base metal and of

[0063] at Nij Nijisan jelement effective for securing the toughness of the welding heat affected zone in high levelsheat

input welding. Therefore: Ni-is contained when it is necessary to attain that effect. When its content is less than 3%;

the amount of ferrite in the welding heat affected zone may become excessive; leading to failure to obtain sufficient

strength and toughness in the welding heat affected zone. When, on the other hand, the Ni content of the base metal

the weld metal. Therefore, when the welded pipe is to be used for conveying a hydrogen-sulfide-containing fluid, at least one of those elements is preferably contained. Mo and Cu are particularly effective for improving the sour gas resistance, and one ease one prever produce a control of an incorporate containing the effect of these elements, the content of each of the elements in the base metal and in the weld metal is preferably not less than 0.5%. As for the base metal, however, when the Mo content exceeds 5%, the toughness in the welding heatraffected zone decreases and, when the W-content exceeds 6% and the Curcontent exceeds 5%, the hot workability lowers. As regards the weld metal, when the Mo content exceeds 5% and when the W-content and Curcontent exceed 6% and 3%, respectively, the weld hot cracking resistance decreases: W [3001] [0068] 51 Accordingly, when these elements are added to the base metal, the content is 1.5-4% and addesirable range of the Curcontent is 1.5-4% and addesirable range of the Curcontent is 1.5-4% and addesirable range of the Curcontent is 1.3%.

3.5

7.5

40

[0069] As for the weld metal, the Mo content is preferably 0.5-5% and each of the Woontent and Curcontent is preferably 0.5-3%. A desirable range of the Mo content is 1.5-4% and a desirable range of the W content and of the [0384] As mentioned hereinabove the wolded black of the work shows excellent SCC revious Schreinfering and Cost in the wolded black of the work of the [0070] Sol: Al-Al is an element effective for deoxidation of the molten steel in base metal production or of the fusion zone in the step of welding. For obtaining the deoxidation effect of Alpit is recommendable; that the solv Al content is not less than 0.001% for the base metal as well as for the weld metal. When on the other hand, the sole Alcontent is over 0.1% falumina clusters readily remain in the base metal or weld metal, hence toughness decreases. A 12000 [0071] PFAccordingly, when Allis added, the sol. All content is preferably 0.001-0.1% for both the base metal and weld metalnAndésirable/content rangéris 0:00140.4%;/moretpreferably/0:00190:01%.easd s painisido er m നെടും ലർ ടോടെ [0072] REV and Zro Each tof these elements is effective for fixing C and Neinthelasteel as the carbidetor initride and thereby-reducing the variations in strength; such as yield strength; of the base material and of the weld metal. When it is necessary to obtain this effect; it is recommended that at least one of the elements is contained. That effect becomes significant at a content of not less than 0.001% for each element. However, when the content of these elements exceeds 0.5% for the base metal or 0.3% for the weld metal, the base metal and weld metal both tend to decrease toughness of not less than 10% by volume and a martensite phase and a more than 20% by. Stanking in a more than 20% by volume and a martensite phase and a more than 20% by volume and a martensite phase and a more than 20% by volume and a martensite phase and a more than 20% by volume and a martensite phase and a more than 20% by volume and a martensite phase and a more than 20% by volume and a martensite phase and a more than 20% by volume and a martensite phase and a more than 20% by volume and a martensite phase and a more than 20% by volume and a martensite phase and a more than 20% by volume and a martensite phase and a more than 20% by volume and a martensite phase and a more than 20% by volume and a more than 20% by volume and a martensite phase and a more than 20% by volume and 20% by [0073] Accordingly, when these elements are added, a desirable content of each telement is 0:001-0.5% more desirably 0.001-0.3%, for the base metal and 0.001-0.3%, more desirably 0.001-0.2%, for the weld metal require each q [0074] Dea and Mg: These elements are effective for improving the hot workability of the base metal? Furthermore, they are also effective for preventing nozzle choking at a time of casting a slab for the base metaliby continuous casting: Therefore, when it is necessary to obtain these effects, at least one of the elements is preferably added. The effects of these elements become significant at a content of not less than 0.0005% each. However, when the content of each exceeds 0.05%, coarse oxide particles thereof tend to remain in the steel, so that the toughness of the base metal tends to decrease and the particles may serve as initiation sites of pitting to reduce the corrosion resistance.

[0075] Accordingly, when these elements are to be contained in the base metal, their content should preferably be 0.0005-0.05% for each of Ca and Mg. A desirable range is 0.0005-0.03%, more desirably 0.0005-0.01%.

[0076] Ca and Mg can fix S in the weld metal and improve the weld hot cracking resistance. For obtaining the effect of these elements; they are preferably contained at a content of not less than 0.0003%. When thowever, the content of these elements is over 0.03%; coarse oxide particles thereof readily remain in the weld metal and; in such cases, the toughness decreases and the coarse oxide particles serve as initiation sites of pitting to possibly decrease the icorrosionaresistance: Therefore, when these elements, are added, and desirable content of each and Mignis this cracking is chemical composition should be selected suit that femile phase occurs in appropriate 5%0.04800000 [0077] Til: In cases where the metallurgical microstructure of the base metal is constituted of a martensite phase and a ferrite phase, the presence of Ti reduces the toughness of the base metal. In particular when the Ti content exceeds 0/1%; the decrease in toughness becomes significant. Therefores the Tircontent of the base metal is preferably not more than 0:1%. A desirable Ti content level is not more than 0:05% and a more desirable one is not more than 0:015%. ·[0078] · On the other hand; This generally added to the weld material to stabilize the welding arc. Therefore, Thremains in the weld metal. The influence of Titon the toughness of the weld metal is relatively slight but at over 0.1% of the toughness tends to decrease. The refore, the Ticontent in the weld metal is desirably not more than 0.1%, more desirably motimore than 0.05%, still more desirably not more than 0.03%. 4095-21 no response evidence or griwollot entimities ed [0079] P. S. Nand O among impurities: Each of them is an element existing as an impurity and the content there of 1.5-4% W: 0-4% and Transfermere than 0 03% and traidisange so wolfared blundalisted wilder and the base market and the base of [0080] When the P content exceeds 0.025%, the corrosion resistance and toughness of the base metal and weld metal tend to decrease. Therefore, the P content is preferably not more than 0.025%. A level not more than 0.015% is more desirable and a level not more than 0.01% is still more desirable.

[0081] When the S content exceeds 0.01%, the hot workability, corrosion resistance and toughness of the base metal and the hot cracking resistance, corrosion resistance and toughness of the weld metal tend to decrease. Therefore, the S content in the base metal and in the weld metal is preferably not more than 0.01%, more desirably not more than

the weld mess. I have a be two the headed on his ac-0.005%, still more desirably not more than 0.002%. [0082] When the N content exceeds 0.02% in the base metal or over 0.05% in the weld metal, the toughness and corrosion resistance of the base metal as hot rolled or as welded show a tendency toward decrease and the toughness and corrosion; resistance of the weld metal tend to decrease. In particular, the toughness of the welding heat affected zone of the base metal and the sour gas resistance of the base metal and of the weld metal tend to decrease. Therefore the Nicontent of the base metal is preferably not more than 0.02% and that of the weld metal not more than 0.05%. For both metals the N content; of not/more than 0.01% is more desirable. A snewdi while and we have the presented [0083] When the O (oxygen) content exceeds 0.01%, the toughness and corrosion resistance of the base metal and of the weld metal tend to decrease of herefore, the O content is desirably not more than 0.01%, more desirably not more than,0:005% and arts is that induced off out the time C.5-5% and the Widentern is the land (1.8-5% - 9 desir 20 Farmence GC one to Preferred; modes, of the chemical, composition: () In the management of the second se proferably 0.6.3% is desirable range of the Melcontinual (1997) and edistrable lange of the Wilcontent and of the [0084] As mentioned hereinabove, the welded pipe of the invention shows excellent SCC resistance when used for the conveyance of crude oils or the like without treatment for dehydration a Further, as described under "Disclosure of Invention", the welded pipe of the invention can have further beneficial characteristics when the base metal or weld metal satisfies the following conditions: with respect to the chemical composition thereof. add to a with the conditions with respect to the chemical composition thereof. [0085] As already mentioned hereinabove, it is desirable that the metallurgical microstructures of the base metal is constituted of 55-90% martensite, phase and 10-45% ferrite phase. For securing such metallurgical microstructures and at the same time obtaining a base metal:excellent in strength;and toughness and further showing such corresion resistance features as sour gas resistance even when the heat treatment after hot rolling in the process of base metal plate production and/or the heat treatment after welding is omitted, it is desirable that the following conditions is satisfied. [0086] eaTher@r,sNirandaTi contents of the base metal should be as follows: Or: 11;20% Transfer of the 0.05%,sNi: 3:7%: And, when the base metal contains Mo, the contents of the elements including these should satisfy the relations (3) and (4) shown below simultaneously. The relation (3) is a condition favorable to obtaining a ferrite phase proportion of not less than 10% by volume and a martensite phase proportion of not more than 90% by volume while the relation (4) is a condition favorable to obtaining a martensite phase proportion of not less than 55% by volume and a ferrite phase proportion;of not,more than 45% by:volume. ਾਰ ਕਰਨ ਸ਼ਾਰ ਕਰਨ ਸ਼ਾਰ ਪਰ ਸ਼ਾਰ ਕਰਨ ਕਰਨ ਸ਼ਾਰ ਹੈ ਜਿਸਤਾ ਸਮਾਹਿਤ ਪ੍ਰਸ਼ਰਤ ਪ੍ਰਸ਼ਰਤ ਪਰ ਸ਼ਾਰ ਹੈ ਜਿਸਤਾ ਸਮਾਹਿਤ ਪ੍ਰਸ਼ਰਤ ਪ੍ਰਸ਼ਰਤ ਪ੍ਰਸ਼ਰਤ ਸ਼ਾਰਤ ਸ਼ [0087] en The symbols of clements in the relations (3) and (4) denote the contents (% by mass) of the respective eleto by are also effective for mevering noticle dhowing at a construction date of the basedeets and benished at the basedeets of the basedeets are the benished in the basedeets of the basedeets are the basedeets and the basedeets are the basedeets Therefore when it is necessary to obtain these alleds and the elements is preferably added. The offects Theo to the thought freely revewed the constant of the constant of the total of the theorem is a sent to the constant of the constant of the theorem is a sent of the total or the total or the theorem is a sent of the total or tends to decrease and the ownoles may serve as iningular to reting to reduce the corresion rawstando (A) Accordingly when these elements are to be 200 - 1/2 - 0M2. F + 1/2 (1905) of the architectual when the content of the con [0076] Caland Mg can fix Similihe weld metal and improve the vield hot cracking resistance. For obtaining the effect [0088]: Referring to the weld metal; it is desirable that it is constituted of martensitic microstructures containing 5-30% austenite, phase, as already mentioned hereinabove. The reason why such metallurgical microstructures are desired is that the cracking (called weld; hot cracking) is to be prevented from occurring in the process of solidification from the mojten state:in the step of welding and the strength and toughness of the weld metal is to be improved. For preventing this cracking, a chemical composition should be selected such that ferrite phase occurs in appropriate amounts in the solidification; process; and in: the cooling process; after solidification; and the ferrite; phase; disappears; while the temperaffertite phase the presence of "il reduces the toughness and past and particular wto 2005 fuodatoralisations affertite phase the presence of "il reduces the toughness and past and pa [0089] Brathose conditions under which ferrite phases can occur in solidification process should be taken into consideration and further, the weld metal should be constituted of martensite microstructure containing 5-30% by volume of austenite phases at ordinary temperature. For that purpose, it is desirable to properly select the contents of the ferriteforming elements Creand Morand austenite forming element. Nit while taking the contents thereof into consideration simultaneously. For the weled-pipe of the present invention, the contents of CraNikMo, and Tilin the base metal should be within the following respective ranges: Cr: 15-20%, Ni: 4-7%, Mo: 15-4% and Ti: not more than 0.015%; the contents of Cr. Ni, Mo, Wand Ti in the weld metal should be within the following respective ranges: Cr. 11-18%, Ni: 5-10%; Mo: 1.5-4%, W: 0-4% and Ti: not more than 0.03%; and the following relations (5) and (6) should be satisfied: assumed in [0030] When the Picontent exceeds 0.025%, the corresponding and foughness of the base metal and well Therefore Doubletone P content is one of the man of 1286. A several to the man of the man of the man of the later of the [OGB1] When the Proprior execute 0.01%, the hot weight on the parameters and tolly mass of the base measured $\frac{25}{160} \leq \frac{1}{180} = \frac{1}{160} = \frac{1$

The relation (5) is directed to the ferrite phase formation in the process of solidification and the term "Cr + Mo - 1.7 x Ni" is an empirical formula indicating the tendency toward ferrite phase formation. As the value of this formula decreases; the ferrite phase yield decreases. However, when the value of this formula is less than 1; no ferrite phase exists:at high temperatures immediately after solidification, hence weld hot cracking tends to occur. On the other hand, when the value of this formula is excessively high, the ferrite phase yield becomes excessive; hence the toughness decreases? The AB digital aminua 35 difference of the mean mean and specified the real monsterer. DOR 100911 ic. The foughness of this weld metal is strongly influenced by the content of O (oxygen). When the relation of Cr + Mo⇔11.7.x Nii≦:13 g/220:x/Olly in:which the O content is: involved, is satisfied the weld metal obtained can have Fig. 27 and Fig. 2B so that the bending amount might action in the bonding emouseendpuotitinaisillus [0092] Referring to the relation (6) the term "Cr + Mo + 1.8 x Ni" is an empirical formula indicating the tendency toward austenite phase formation. When the value of this formula is less than 25, the austenite phase yield is slight and no sufficient toughness, can be obtained. Conversely, when the value of this formula exceeds 30 the austenite phase yield becomes excessive, hence sufficient tensile strength and yield strength cannot be secured and the modules [0093] o'The termo sufficient tensile strength as used referring to the weld metal means that since welded joint tensile test; failure occurs in the base metal portion but not in the weld metal portion. For the welded pipe of the invention; the weld metal should have a tensile strength of not less than 650 MPa so that the strength can be not below the X-80 grade (not less than 551 MPatintyleld strength). If the arm is only saidle as observed not believe off. [A016] 100941 When the base metal satisfies the above relations (3) and (4) and the weld metal satisfies the relations (5): and (6), the welded pipe of the invention can become one further improved in characteristics. See anomics or test to [0095]ab in addition to the above features of the welded pipe, when the chemical composition of the base metal comprises: C: not more than 0:05%; Sithot more than 0.5%; Mn; not more than 11%; Cr. 9-17%; Nif 0-9%; Will 0-1%; Cut 0-3%, V: 0-0.3%, Ca:0-0.01%, Ti: not more than 0.1% and the balance: Fe and impurities, and the chemical composition of the weld metal comprises: C: not more than 0.05%, Si: not more than 0.5%, Mn: not more than 4%, Or 9-20%, Ni: 0-9%,†W: 0:3%; Cu:: 0-3%; V:: 0-0:2%; Ca:: 0-0:01%, B:: 0-0:01%; Ti: not-more!than=0.1% and the balance: Feliand impurities, the welded pipe shows the highest level of SCC resistance: "" do bas "" about disve saw more than the Sour gas resistance (est.) The size and number of rost space erric of the same at in the SOC resistance test. The Userasia pipe for:a:pipeline: Test constated to a local conditions of the same and the same conditions of bending successful and pipeline in the same and the same of the same and the same bending amount Y (mm) were subjected to autodate reprint the subplace instruent conditions were as follows [0096] to The welded piperof the invention is most effectively used as a pipe for a pipeline for conveying a crude oil or natural:gas while omitting the treatment for dehydration. In particular, when the side edge of one pipe is joined to the side edge of another by welding during a construction of a pipeline, the weld metal portion and the heat affected zone of the base metal need not be subjected to postweld heat treatment. Therefore the pipeline can be used as welded condition. The side edge-to-side edge welding of pipes can be realized by applying such a welding method as the SAW method, TIG method, MIGhmethod or MAGhmethod son ... & order as here and leave white the deliberation of the leave and a 180 for

Method of producing the welded pipe:

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Example

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[0097] The welded pipe of the present invention can be produced by a conventional method of producing ordinary welded pipes? A general method of production is as follows: a standard blaw owt bas slattern send evil to another identical [0098] First, a hot strip or thick plate is cut to a width substantially equal to the outer circumference of the product pipe Then; it is formed into a cylindrical form by the UOE method comprising forming by means of a Cipress; a Upress and an O-press. The joining portions are then welded together by the SAW method to produce a welded pipe in the forming stage, the UO method, spiral method, roll bending method or like method may also be employed as in simulation. [0099] ParThe welding conditions as well as the flux and welding wire can be selected taking into consideration the chemical composition of the weld metal and other factors. In cases where a fine adjustment in hardness becomes necessary, tempering onlike treatment may be carried out. The size of each to salve API standard The size of each to the API standard The size of each to the API standard The size of each to the API standard The Size of the API standard The API standard The Size of the Size of the API standard The Size of the Size [0100] The chemical composition of the base metal to be used can adequately be selected considering the above [0109] For the thick plates given the symbols E. O or fedig-bellew editoreauthément of gnibroson anoitibhéo [0101] stAs for the method of producing the hot strip or thick plate; namely the base metal; any of the methods in conventional use may be employed. The hot strip or thick plate may be produced by the method comprising hot rolling accontinuously cast slab or the method comprising blooming a steel ingot, followed by hot rolling went to not lead moderned [0102] In producing the base metal with a ferrite phase proportion of 10-45% by volume (martensite phase proportion) of 55-90% by volume); the heating temperature for the material prior to hot rolling is desirably 1100°C-1250°C 0At a heating temperature exceeding 1250°C; ferrite phases may precipitate abundantly in some instances with the result that the metallurgical microstructures of the product cannot be constituted mainly of a martensite phase. At below 1100°C; the material steel shows high deformation resistance, hence is difficult to hot roll the distribution of the distribution of the material steel shows high deformation resistance, hence is difficult to hot roll the distribution of the dist the syribble denotice the will metal. Two test surprise the line will 25 4 min with and 185 and long for him and the conservation between the contraction of the and a pid in balawar as roughly to the con-

EXAMPLES of the second softenes to exercise out to the content of the content of

[0103] The test methods used in Examples 1 to 3 in common are as follows: Fig. 3 is a schematic drawing showing the sectional structure of the weld portion formed by the single pass weld material. 7 used in Examples, 1 and 2 to be mentioned later-herein. www. scones earneds a class of the contract of the specific and the second subtraction of the contract SCC resistance test: The size of test specimens was: thickness 5 mm x width 25.4 mm x length 165 mm. For each set of test conditions; one test specimen was prepared in Example 1 and two specimens were prepared in Example 2 and Example 3. A bending stress was applied by setting the test specimen 5 on a jig 6 for causing bending, as shown in Fig. 2A and Fig. 2B, so that the bending amount might arrive at Y (mm). "Y" is the bending amount arrived at when a stress equal in value to the yield strength (YS) of the base metal is applied as or (bending stress) appearing in the equation(shown) in Fig. 2B, at room temperature. The test specimens with this bending amount given were subjected to autoclave treatment. The treatment conditions were as follows: atmosphere & CO20gas at 30 atmospheres, test solution - 10% (by mass) aqueous NaCl solution at 100°C, immersion time in solution 5720 hours. The test specimens after treatment were observed by the eye for occurrence of cracking. In cases where the occurrence or nonoccurrence of cracking could not be confirmed definitely by visual observation alone, the section thereof was polished and then observed for occurrence or nonoccurence of cracking undersan optical:microscope.enanatis eved blacks taken black [0104] The evaluation was made as follows. When the number of test specimens was one, the case where no crack was found was judged; good !! and the case where cracking was found was judged; defective !! >: When the number of test specimens was 2, the case where either specimen showed no cracking was judged good "O" the case where one specimen showed cracking was judged poor: "A" and the case where both showed cracking was judged defective "X" CO2 resistance test: The size of test specimens was: thickness 2 mm x width 20 mm x length 50 mm. The test specimens, were subjected to autoclave treatment under the same conditions ascin the SCC resistance test and ex-[0105] The CO2 resistance evaluation was made as follows. The case where the dimensional loss was not more than 1 mm was evaluated good "O" and other cases were evaluated defective "X". swords edic peblew and seithudmi Sour gas resistance test: The size and number of test specimens were the same as in the SCC resistance test. The conditions of bending stress application were the same as in the SCC resistance test. The test-specimens given the bending amount Y (mm) were subjected to autoclave treatment. The autoclave treatment conditions were as follows: atmosphere 5 CO2 gas at 30 atmospheres with H2S gas at a partial pressure of 0.03 atmosphere stest solution 134 0% (by mass) aqueous NaCl solution with pH.4.5 at a temperature of 25°C; immersion time 720 hours: The test specimens after treatment were observed by the eye for occurrence of cracking. In cases where the occurrence or nonoccurrence ofecracking could not be confirmed definitely by visual observation alone, the section thereof was polished; and then observed for occurrence, or no noccurrence, of cracking under anaoptical microscope a abla-of-aging hid and invitioned [0106] The evaluation criteria were the same as in the SCC resistance test mentioned above. bodient Elitabeth portions

Example 1

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Method of moducing the melacti pipo

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[0107] In Example 1, the relation between the weld bead shape and the SCO resistance was examined. Further the combinations of five base metals and two weld materials differing in chemical composition; metallurgical microstructures and tensile; characteristics; were; also, examined: what a substance with substance and the substance of the characteristics; were; also, examined: what a substance of the characteristics; were; also, examined: what a substance of the characteristics; were; also, examined: what a substance of the characteristics; were; also, examined: what a substance of the characteristics; were also, examined: what a substance of the characteristics; were also, examined: what a substance of the characteristics; which is a sub [0108] InaTable 1; theresare shown the chemical compositions and metallurgical microstructures of 5 thick plates (symbols: A-E); namely:base-metals; the chemical compositions of the weld materials; (symbols: F; and G) used and the chemical compositions; and metallurgical, microstructures of the weld metals obtained from the combinations; of these base metals and weld materials. All the base metals were martensitic stainless steels containing ferrite phase Each thick plate had been adjusted so that its strength was of the X-80 grade (not less than 80 ksi (55.1 MPa) in yield strength) defined in the API standard. The size of each thick plates for welding test was as follows: 12:7-25.4 mm; thick: 300 mm [0100] The chemical composition of the base metal to an even har addouglely be selected con.gnol-milt.bna; ebiw [0109] For the thick plates given the symbols B, D or E, steel plate specimens (2) specimens for the one given the symbol B) for actual pipe:making testing 1920 mm wide and 6 m long; were prepared and four large-diameter; thick; wall:welded.pipes; 61,0;mm; in outside; diameter; and 6 m in length, were:produced:by, the SAW method: The chemical composition of the weld:material:used:in:pipe;making was that shown in Table it under the symbol G. The tests:made for the welded pipes: correspond to the test numbers 33-36 in: Table 4 are a still lead and and producing in [20102] [01/10]) **As; for) the 300-mm-wide thick plates for welding testing; one edge side thereof in the width direction was subjected to bevel machining according to the plate thickness and the beveled portions were joined and welded together by the single-pass, SAW, method. Fig. 3 shows the sectional structure of the weld bead portion of the test specimen after this welding (hereinafter) referred to also as "weld joint"). The symbol 7 denotes the thick plate (base metal) and the symbol 2 denotes the weld metal. Two test specimens 5, 5 mm thick, 25.4 mm wide and 165 mm long, for fourpoint bending testing, with a weld bead, were each taken from the site of that weld joint as indicated in Fig. 4 and

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subjected to corrosion testing. As for the 6 m-long welded pipes, test specimens 5 for corrosion testing were each taken from the site shown in Fig. 5 judged to be the highest-in-the-weld bead portion h.

[0111] As for the weld metal, two chemical compositions were employed and the chemical compositions of the weld materials of the weld joint portions mentioned above are also shown in Table 1. For 32 single pass-welded materials and 4 welded pipe test specimens, the test specimen sizes and test specimen weld bead shapes as formed are shown in Tables 2 to 4 for the respective test numbers.

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•	[0112] Among the single pass welded materials shown in Table 2 to Table 4	4, the materials of specimen numbers 3-7
	were the same as those of the single pass welded material of specimen n	number 2 and the materials of specimer
	numbers 18-21 were the same as the single pass welded material of specin	
	other than the length L had been cut off by cutting treatment to the same he	
5	[0113] And each of the thus-obtained single pass weld materials and well	ded nines was subjected to the following
•	[0113] And, each of the thus-obtained single pass weld materials and well	tion as a subjected to the tollowing
	tests as welded, hamely-without any heat treatment after welding.	<u>;</u>
	[0114] Each test specimen was subjected to tensile test, weld bead shape	
	resistance test and sour gas resistance test:	ACC RESTREAMED
	[0115] The tensile test conditions in Example 1 were as follows:	Andrews a state of the state of
10	[0116] For both the single pass weld materials and welded pipes, the test sp	pecimen sampling site was in the direction
	perpendicular to the steel plate rolling direction for the base metal portions and	d in the direction tangential to the direction
	of seam welding for the base metal portions and the size of each test spe	
	diameter and 60 mm in parallel portion length. The test temperature was	A PARTICULAR PROPERTY AND A SECTION AND ADDRESS OF THE PARTICULAR
	temperature 100°C, the yield strength (YS) of the base metal and of the	
15 ·	temperature, the tensile strength (TS) and yield strength (YS) of each of the	
•••	[0117] The results of the above tests are also shown in Tables 2 to 4.	
	[0118] The results shown in Tables 2-to 4 indicate the following.	2 2 - 2 - 1
•	[0116] The results shown in lables 2-to 4 indicate the following	10 45 46 00 00 05 00 00 00 01
•	[0119] The single pass welded portions (specimen numbers 6-8, 10, 11, 1	
•	32) and welded pipes (specimen numbers 33-36) satisfying the conditions def	
20	to the weld bead shape all showed good SCC resistance and were excellent	
	[0120] As regards the sour gas resistance, the single pass welded portion	ns and welded pipes other than those o
	specimen numbers 20-23, 28, 29, 31 and 32 where the Mo content in the ba	· · · · · · · · · · · · · · · · · · ·
	From these results, it was confirmed that when sour gas resistance is rec	——————————————————————————————————————
	measure for improving the sour gas resistance in combination with measure	es for satisfying the conditions defined by
<i>25</i>	the present invention with respect to the weld bead shape.	
	[0121] On the other hand, those single pass welded portions which failed	d to satisfy the conditions defined by the
	present invention concerning the weld-bead shape (specimen numbers-1-5, 9	9-12-14-17-19, 24, 27, 30) were all poor
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30	in SCC resistance. [9] [9] [9] [9] [9] [9] [9] [9] [9] [9]	bead shape satisfied the weld bead shape
30	in SCC resistance. g g g g g g g g g g	bead shape satisfied the weld bead shape
30	in SCC resistance. [9] [9] [0122] The specimens numbered 20-23, 28, 29, 31, 32 and 36 whose weld be conditions defined by the present invention were excellent in SCC resistance gas resistance was poor, however.	bead shape satisfied the weld bead shape
30	in SCC resistance. [9] [9] [9] [9] [9] [9] [9] [9] [9] [9]	bead shape satisfied the weld bead shape
	in SCC resistance. [9] [9] [10122] The specimens numbered 20-23, 28, 29, 31, 32 and 36 whose weld be conditions defined by the present invention were excellent in SCC resistance gas resistance was poor, however.	pead shape satisfied the weld bead shape and further in CO ₂ resistance. Their soul
<i>30</i>	[0122] The specimens numbered 20-23, 28, 29, 31, 32 and 36 whose weld be conditions defined by the present invention were excellent in SCC resistance gas resistance was poor, however. [0123] In Example 2, the welded pipes satisfying the weld bead shape continuous conditions defined by the present invention were excellent in SCC resistance gas resistance was poor, however.	and further in CO ₂ resistance. Their sould be administration of the invention, namely
	[0122] The specimens numbered 20-23, 28, 29, 31, 32 and 36 whose weld be conditions defined by the present invention were excellent in SCC resistance gas resistance was poor, however. Example 2 [0123] In Example 2, the welded pipes satisfying the weld bead shape conwelded pipes showing good SCC resistance, were examined to find out the definition of	and further in CO ₂ resistance. Their sound itions defined by the invention, namely esirable conditions concerning the chemical and shape and shape and further in CO ₂ resistance. Their sound itions defined by the invention, namely esirable conditions concerning the chemical and shape and shap
	[0122] The specimens numbered 20-23, 28, 29, 31, 32 and 36 whose weld be conditions defined by the present invention were excellent in SCC resistance gas resistance was poor, however. Example 2 [0123] In Example 2, the welded pipes satisfying the weld bead shape conwelded pipes showing good SCC resistance, were examined to find out the decical composition and metallurgical microstructure of the base metal. In particular, the specimens of the base metal.	pead shape satisfied the weld bead shape and further in CO ₂ resistance. Their sould be added to be satisfied by the invention, namely esirable conditions concerning the chemical articles and the conditions to be satisfied by the
	[0122] The specimens numbered 20-23, 28, 29, 31, 32 and 36 whose weld be conditions defined by the present invention were excellent in SCC resistance gas resistance was poof, however. Example 2 [0123] In Example 2, the welded pipes satisfying the weld bead shape conwelded pipes showing good SCC resistance, were examined to find out the defical composition and metallurgical microstructure of the base metal. In participase metal, even as welded, to have good sour gas resistance and toughned.	nditions defined by the invention, namely esirable conditions to be satisfied by the satisf
35	[0122] The specimens numbered 20-23, 28, 29, 31, 32 and 36 whose weld be conditions defined by the present invention were excellent in SCC resistance gas resistance was poor, however. Example 2 [0123] In Example 2, the welded pipes satisfying the weld bead shape conwelded pipes showing good SCC resistance, were examined to find out the decical composition and metallurgical microstructure of the base metal. In particulations metall, even as welded, to have good sour gas resistance and toughner. [0124] The chemical compositions of 26 kinds of steel (base metals) test	and further in CO ₂ resistance. Their sould be ad shape and further in CO ₂ resistance. Their sould be added to be satisfied by the satisfie
	[0122] The specimens numbered 20-23, 28, 29, 31, 32 and 36 whose weld be conditions defined by the present invention were excellent in SCC resistance gas resistance was poor, however. Example 2 [0123] In Example 2, the welded pipes satisfying the weld bead shape conwelded pipes showing good SCC resistance, were examined to find out the decical composition and metallurgical microstructure of the base metal. In participate metal, even as welded to have good sour gas resistance and toughner [0124] The chemical compositions of 26 kinds of steel (base metals) test designated Nos. a-u and x-z were each worked up into a plate, 25 mm thick.	nditions defined by the invention, namely esirable conditions to be satisfied by the satisf
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35	[0122] The specimens numbered 20-23, 28, 29, 31, 32 and 36 whose weld be conditions defined by the present invention were excellent in SCC resistance gas resistance was poor, however. Example 2 [0123] In Example 2, the welded pipes satisfying the weld bead shape conwelded pipes showing good SCC resistance, were examined to find out the decical composition and metallurgical microstructure of the base metal. In partice base metal, even as welded to have good sour gas resistance and toughner [0124] The chemical compositions of 26 kinds of steel (base metals) test designated Nos. a-u, and x-z were each worked up into a plate, 25 mm thick, process of meliting each steel in a small melting furnace, casting it into an ingolator forging the same into a slub and, further, hot rolling the resulting slab up	nditions defined by the invention, namely esirable conditions to be satisfied by the satisf
35	[0122] The specimens numbered 20-23, 28, 29, 31, 32 and 36 whose weld be conditions defined by the present invention were excellent in SCC resistance gas resistance was poor, however. Example 2 [0123] In Example 2, the welded pipes satisfying the weld bead shape conwelded pipes showing good SCC resistance, were examined to find out the decical composition and metallurgical microstructure of the base metal. In participate metal, even as welded, to have good sour gas resistance and toughner [0124] The chemical compositions of 26 kinds of steel (base metals) test designated Nos a-u and x-z were each worked up into a plate, 25 mm thick process of meliting each steel in a small melting furnace, casting it into an ingolar contract.	nditions defined by the invention, namely esirable conditions to be satisfied by the satisf
35	[0122] The specimens numbered 20-23, 28, 29, 31, 32 and 36 whose weld be conditions defined by the present invention were excellent in SCC resistance gas resistance was poor, however. [0123] In Example 2, the welded pipes satisfying the weld bead shape conwelded pipes showing good SCC resistance, were examined to find out the decical composition and metallurgical microstructure of the base metal. In partice base metal, even as welded to have good sour gas resistance and toughner [0124]. The chemical compositions of 26 kinds of steel (base metals) test designated Nos. a-u and x-z were each worked up into a plate, 25 mm thick process of melting each steel in a small melting furnace, casting it into an ingoin hot forging the same into a slub and, further, hot rolling the resulting slab upasses = 5, finishing temperature = 980°C. The steel designated Nos.s-u were No.v and w were thick plates, 19 mm in thickness, for pipe production as pro-	nditions defined by the invention, namely estrable conditions to be satisfied by the satisf
35	[0122] The specimens numbered 20-23, 28, 29, 31, 32 and 36 whose weld be conditions defined by the present invention were excellent in SCC resistance gas resistance was poor, however. Example 2 [0123] In Example 2, the welded pipes satisfying the weld bead shape conwelded pipes showing good SCC resistance, were examined to find out the decical composition and metallurgical microstructure of the base metal. In partice base metal, even as welded to have good sour gas resistance and toughner [0124]. The chemical compositions of 26 kinds of steel (base metals) test designated Nos.a-u and x-z were each worked up into a plate, 25 mm thick process of melting each steel in a small melting furnace, casting it into an ingoth hot forging the same into a slub and, further, hot rolling the resulting slab upasses = 5, finishing temperature = 980°C. The steel designated Nos.s-u were	nditions defined by the invention, namely estrable conditions to be satisfied by the satisf
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35 40 45	[0122] The specimens numbered 20-23, 28, 29, 31, 32 and 36 whose weld be conditions defined by the present invention were excellent in SCC resistance gas resistance was poor, however. [0123] In Example 2, the welded pipes satisfying the weld bead shape conwelded pipes showing good SCC resistance, were examined to find out the decical composition and metallurgical microstructure of the base metal. In partice base metal, even as welded to have good sour gas resistance and toughner [0124]. The chemical compositions of 26 kinds of steel (base metals) test designated Nos. a-u and x-z were each worked up into a plate, 25 mm thick process of melting each steel in a small melting furnace, casting it into an ingoin hot forging the same into a slub and, further, hot rolling the resulting slab upasses = 5, finishing temperature = 980°C. The steel designated Nos.s-u were No.v and w were thick plates, 19 mm in thickness, for pipe production as pro-	nditions defined by the invention, namely estrable conditions to be satisfied by the satisf
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EP 1 179 380 A1 [0125] A welding wire, 4 mm in diameter, containing C: 0.01%, Cr: 12%, Ni: 9% and Mo: 3% by mass and a high basicity bond flux were prepared as the weld materials. [0126] And, mimicking the actual welded pipe production process, the side edges, parallel to the direction of rolling, of each plate prepared were worked to give Y shape bevels with an angle of 60 degrees and a root face height of 13mm and the worked portions were butt welded. Single pass welding was performed by the SAW method and the weld heat input was 7.5 kJ/mm. [0127] Then, the test specimens mentioned below were taken from the base metal portion and butt welded portion after welding and examined for mechanical properties (yield strength and toughness) and sour gas resistance. [0128] The tensile test specimens for yield strength measurement were taken from a site in the direction perpendicular to the direction of rolling of the base metal and had the shape of a round bar with a diameter of 4 mm and a gauge The Charpy impact test specimens for toughness measurement were taken from a site in the direction perpendicular to the direction of rolling and had the shape of No. 4 specimen standardized in Jis Z 2202 (1980) (length: 75 mm, width: 10 mm, notch: 2 mm V). The Charpy impact test specimens were cut out from both the base metal and butt welded portion. The No. 4 specimens cut out from the butt welded portion were notched in the weld bond portion (boundary between the fusion zone and unfused zone). The toughness was evaluated in terms of vTrs. [0130] The test specimens for Sour gas resistance test were taken from a site in the direction perpendicular to the direction of folling and were V-notched 4-point bent beam test specimens 2 mm in thickness, 10 mm in width and 75 mm in length. As for the number of specimens, two were taken from the middle in the direction of thickness for the base metal and for the butt welded portion. The 4-point bent beam test specimens cut out from the butt welded portion were notched in the weld bond portion in the same manner as the above-mentioned Charpy impact test specimens. [0131] The bending stress applied in sour gas resistance test was as mentioned above. The specimen treatment conditions were as follows: atmosphere - carbon dioxide gas at a partial pressure of 30 atmospheres and H₂S gas at a partial pressure of 0.01 atmosphere, solution - an aqueous solution containing 5% by mass of NaCl at a temperature of 25°C, immersion time - 200 hours? The sour gas resistance was evaluated by the method mentioned above. [0132] The results of material characteristics evaluation are shown in Table 6, together with the calculated values for confirming the relations (3) and (4) defined by the present invention concerning the desirable chemical composition of the base metal.

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The weld metals were evaluated for weld hot cracking resistance based on the occurrence or nonoccurrence of cracking in the weld metal portions of the above welded pipes. When no crack was observed, the weld hot cracking resistance was indicated by "O" (good) and when cracking was observed by "X" (poor). [0141] The test specimens for tensile test were No. 5 specimens standardized in JIS Z 2201 with a parallel portion length of 110 mm and a gauge length of 100 mm. The specimens were taken in the direction perpendicular to the fusion line so that the parallel portion contained-the weld metal, welding heat affected zone and base-metal. The test temperature was room temperature. The test results were indicated by "O" (good) when the failure occurred in the base metal portion and by "X" (poor) when the failure occurred in the weld metal portion. [0142] The Charpy impact test specimens for toughness measurement were taken from each weld joint in the direction perpendicular to the weld bead. The specimens had the same shape and size as in Example 2 and the notch of each specimen was formed so that it was in the middle of the weld metal. The test temperature was "30," C and the toughness was evaluated in terms of absorbed energy vE -30°C. The toughness was evaluated as good "O" when the absorbed energy was not less than 50 Jand as poor "X" when it was less than 50 J. [0143] The test specimens for sour gas résistance test had the shape of a plate, 5 mm in thickness, 20 mm in width and 165 mm in parallel portion length. The specimens were taken in the direction perpendicular to the fusion line so that the fusion line (middle portion of the weld bead) was located in the middle of the specimen length. As for the reinforcement of weld, one side retained it and the reverse side was ground smoothly. The method of bending stress application and the autoclave treatment conditions were as mentioned above. [0144] The workability was evaluated by a test comprising bending the butt welded plate at a radius of curvature which was twice the plate thickness. The test results were indicated by "O" (good workability) when no cracking, crush or like trouble occurred and by "X" (poor workability) for other cases. The test results are summarized in Table 9. 25 • 2 ₩. 35 194 1 hours -150 5 10 mg Ċ 2,1 100 C 世紀 1.12 J. 13 F. Ĵ . 2. (4). 50 (T) 基 **E** 二二 \Diamond

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[0146] The specimens numbered 4, 6-8, 14 and 16-18; all satisfying the relations (5) and (6) defined by the present invention, gave good results in all characteristics, namely sour gas resistance, toughness, weld not cracking resistance, workability and tensile properties. The specimen numbered 13, however, which satisfied the relations (5) and (6), was inferior in sour gas resistance since the Cricontent was 10.4%, thus rather low. From this result, it was confirmed that for providing the weld metal with sour gas resistance, it is recommendable to increase the Cricontent to 11% or above while satisfying the relations (5) and (6) simultaneously.

[0147] The specimens given other numbers than those mentioned above failed to satisfy at least one of the relations (5) and (6) and, except for specimen No. 5; they were poor in at least one of sour gas resistance and toughness. The specimen numbered 5, which was:an example in which the austenite phase proportion in the weld metal portion was as high as 40% by volume, was good in sour gas resistance and toughness but too low in tensile strength.

INDUSTRIAL APPLICABILITY The contents of P. S and O (oxygon) among the inicurities action both the bace metal and wold metal in action of the statements of the statements of the statement of th

[0148] The martensitic stainless steel welded pipe of the inventions is excellent in corrosion resistance of pipe inside surface weld portion, in particular in SCC resistance, in spite of its being a large-diameter, thick-wall welded pipe. Further, the sour gas resistance, toughness and weld hot cracking resistance can be improved by selecting the chemical composition. Therefore, it is very suited for use as a pipe for a pipeline for conveying a crude oil or natural gas highly corrosive to metals while omitting dehydration treatment.

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Claims

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A martensitic stainless steel welded pipe which comprises a base metal which is a stainless steel containing, on the mass % basis, not more than 0.05% of C and 9-20% of Cr and having a metallurgical microstructure comprising a full martensite phase or a martensite phase as the main constituent with a ferrite phase contained therein, and a seam weld metal which is a stainless steel containing, on the mass % basis, not more than 0.1% of C and 7-20% of Cr and having a metallurgical microstructure comprising a martensite phase as the main constituent with an austenite phase contained therein, a seam weld bead on the inside surface satisfying the following relation(1):

$L \le 0.2 \times W \tag{1}$

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 $C_{M,k}$

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where L: the length of the portions of the seam weld bead showing a value of h which exceeds 1.25 as calculated by the expression (2) shown below:

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have the following chemical compositions on the med. The place

where

H: the height of the bead from the pipe inside surface (mm),

W: the width of the bead (mm),

YS_{B100}: the yield strength of the base metal at 100°C (MPa),

YS_{w100}: the yield strength of the weld metal at 100°C (MPa).

2. A welded pipe as claimed in Claim 1; wherein the metallurgical microstructure of the base metal is constituted of, on the volume % basis, 55-90% martensite phase and 10-45% ferrite phase and that of the weld metal is constituted of, on the volume % basis, 70-95% martensite phase and 5-30% austenite phase, and wherein the chemical compositions of the base metal and weld metal are, on the mass, % basis, as follows:

					The third that the terms of the
	20 F	Base metal: Si	0.01-1%,	sol. Al·	0.001-0.1%,
	. *	asithugal of Mn	0.05-2%,	V	0-0.5%,
	, american series of the serie		0-9%,	Zr	-0-0.5%,
55	อเลอ โดยประกาณ (เ ก. 90เก ต	Mo a phiveynge tot note to	_0-5% ,	Ca _{mo} n to	0-0.05% Vna n. vathogaty pa av
		W	0-6%,		0-0.05%,
		Cu	0-5%,	Ti	not more than 0.1%,

	•	•	•		Section 2
The second section is the		,	Balance	Fe. impurities:	The state of the s
THE REPORT OF THE WEST	Wold metal: Si	0.01-1%	sol Al	10.001-0.1%	Million 197 y 197
के संग्राहरू वर्गण किया है। यह	Set Subtraction of the	0.01-176,	SOI. (A)	างอาจ (วัน ฮันนะ อาการ	ter end on a trial pla
the experience of the second	O and sesman Min	.0.05-2%,	y .	0-0.3%	្នាយស្រាស់ក្រៅក្រោះប្រភព្ធ ក
	Ni i	0-10%,	Zramatre	0-0.3%, 57.3 7.3	मुख्या नवा जुन पृष्टामाळ राज्य
राजातीच इसी पिलाल स्टब्स	Is yielde at a simoye	.0-5%,			
in in assumed one as	Morrest sag mode Wild	. 0-3%,	rcMg∋ o∾ r	o-0.03%;ടണ്ടെ ത	เลยกหมาติดตราส เลามาติ
रक्षण वर्षाकर व पराकृत हो पर		· ·	SOTT OFFW OF	not more than 0.1% /	palaimen numbared 5
क्ष्मित्र स्व	ness out the low the c	9 1 31 1 CH .	· Balance	Fei impurities: 54 50	as high as 40% by vor
		<u> </u>			

the contents of P, S and O (oxygen) among the impurities being, for both the base metal and weld metal, P: not more than 0.025%, S: not more than 0.01% and O: not more than 0.01%, and the content of N being not more an equal to a some sections of the least of the section of the base metal and not more than 0.05% for the weld metal.

A welded pipe as claimed in Claim 1 or 2, wherein the contents of Cr. Ni and Ti in the base metal are, on the mass % basis, Cr. 11-20%, Ni: 3-7% and Ti: not more than 0.05%, with the following relations (3) and (4) being satisfied:

Cr + 1.5Mo - Ni - 0.4Cu - 14 ≥ 0 Clain:s

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ro grimsmon per Reiniela à si doinn fatCr∓d.5Mb 42Ni.-0:8Cùid12i5:≦i0ibleu leeta socialet bitlanehem A. (4) er in neving elimetallurgical inforcessitations graver in the the mass of search not move than 0.05% of Cland Richard

4.0. A welded pipe as claimed in any of Claims 1 to 3, wherein the contents of Cr. Ni, Mo and Ti in the base metal are, on the mass % basis, Cr. 15-20%, Ni. 4-7%, Mo. 1.5-4% and Ti. not more than 0.015%, and the contents of Cr, Ni, Mo, W and Ti in the weld metal are, on the mass % basis, Cr. 11-18%, Ni. 5-10%, Mo: 1.5-4%, W: 0-4% and Ti: not more than 0.03%, with the chemical composition of the weld metal satisfying the following relations (5) and (6):

- 1 ≤ Cr + Mo - 1.7Ni ≤ 13 - 220 x O (oxygen)

where Li the length of the nortions of the seam watch that a consular value of a which exceeds 1.25 as calculated by the expression (2) chiral param

> $25 \le Cr + Mo + 1.8Ni \le 30$. (6)

India Strain Wear State and 5. A welded pipe as claimed in Claim 1 or 2, wherein the base metal and the weld metal in the seam portion respectively have the following chemical compositions on the mass % basis: or saine

	Base metal:	С	not more than (0.05%, Cı	l and a		a magain to some
		Si	not more than (0.5%, V	· ///////	right of the beautient	radi W
	·	Mn	not more than 1	1%,Ca		the vield strew%10.0-0	
		Cr	9-17%, - :::		weld ma	not more than 0,1%,~	DOLWEY
	_	Ni	0-9%,		•	Fe, impurities,	
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solutramo e leis	`Weld'metal: '=	:Çue i	not more than (0.05% _, 5.08.8	กต อยุรม	' Cú: 0-3% ;: \	nulovi trilina
าย ดูกษาร์สลใ 20ท	e and wherein :	Si ^{do}	inot more than (0.5%, ******(V)	edensit	70-0:2%, Tered no emul	of on the ve
	1	"Mn"	hot more than i	1%, Ca	merai g	the base metal % Fo. 000	to should be
	e de en em e un conseil in en	-Cr	9-20%,	· · · · · · · · · · · · · · · · · · ·		-0-0:01%;	
		Ni .C	0-9%,	" · · · · · · · · · · · · · · · · · · ·	0 :2	-0-0:01%; not more than 0.1%,	
-	•	W 1	· 0-3%,	**************************************		Fe, impurities.	·

6. Use of a welded pipe as described in any of Claims 1 to 5, in a line pipe for conveying a crude oil or natural gas with no dehydration treatment. and, markéthan 0,1%

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Fig. 17

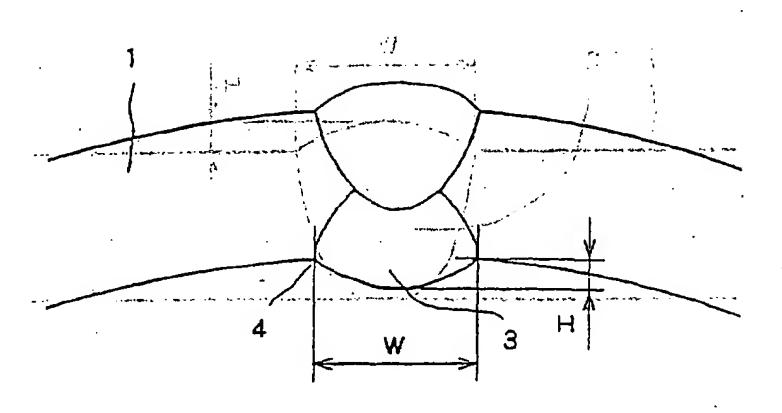


Fig. 2A

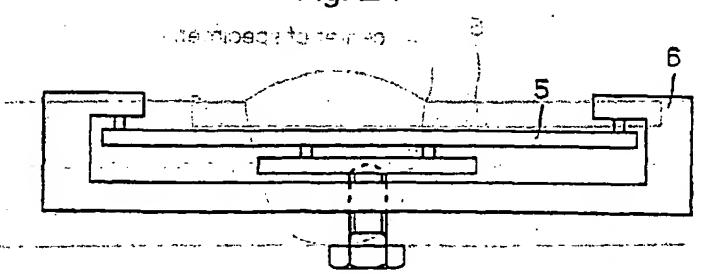


Fig. 2B

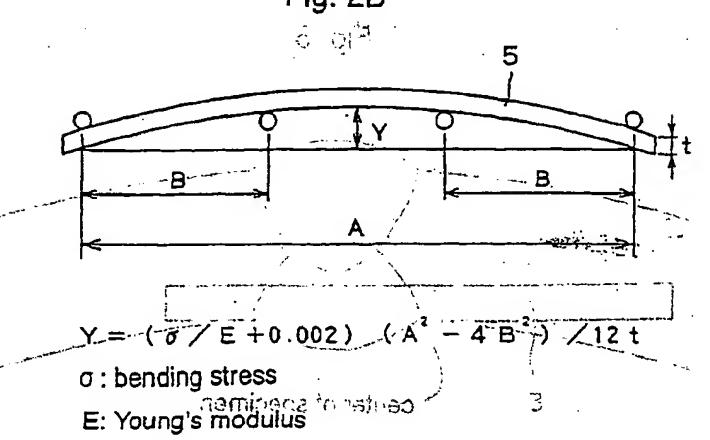


Fig. 3

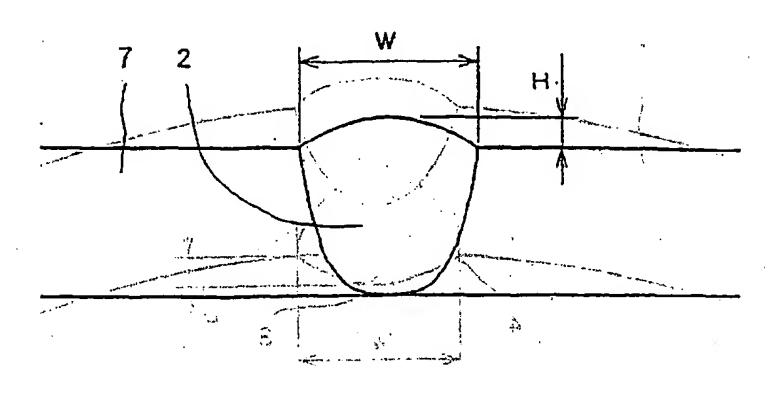
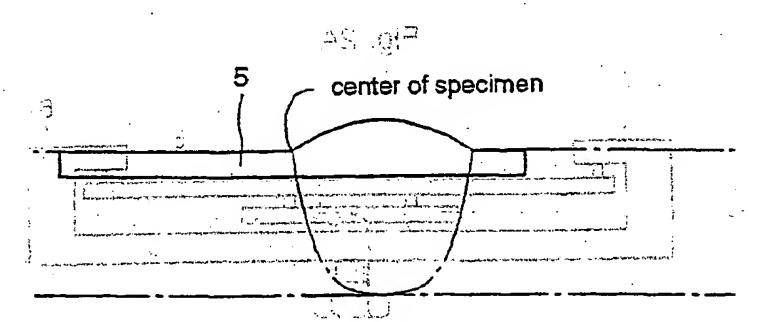
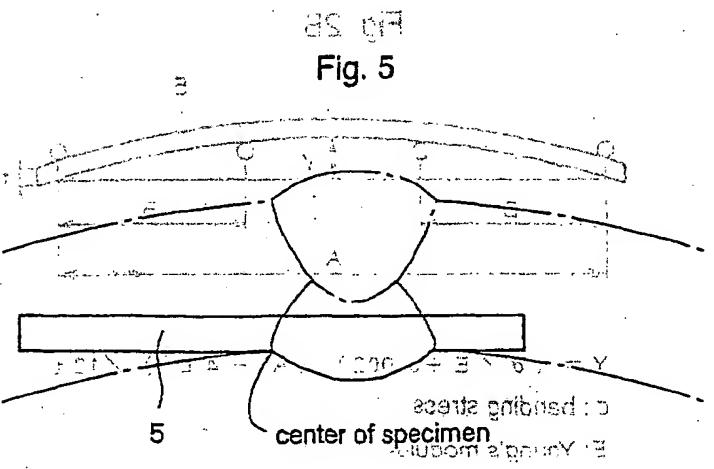


Fig. 4





INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP00/05296

		FCI/C	1200/05296
	SIFICATION OF SUBJECT MATTER C1 B23K9/02, 9/23		
1110,	CI 623107 627 3723		
According to	o International Patent Classification (IPC) or to both na	ational classification and IPC	
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Electronic d	sts base consulted during the international search (nam	e of data base and, where practicable, se	earch terms used)
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C. DOCU	MENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where ap		Relevant to claim No.
.	JP, 6-299233, A (Hitachi Ltd.) 25 October, 1994 (25.10.94) (Fa		1-6
A	JP, 9-29429, A (Toshiba Corpora	ation),	1-6
	04 February, 1997 (04.02.97) (1		
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Further	documents are listed in the continuation of Box C.	See patent family annex.	
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